

## WHAT IS CLAIMED IS:

1. A process for the production of elemental sulfur from an acid gas feed stream containing hydrogen sulfide, the process comprising the steps of:

5                   contacting a feed gas mixture comprising at least a portion of the acid gas feed stream and sulfur dioxide with a Claus conversion catalyst in a single Claus catalytic reaction zone at a temperature effective for the reaction between hydrogen sulfide and sulfur dioxide to form a product gas effluent comprising elemental  
10                   sulfur and water;

                  cooling the product gas effluent to condense and separate elemental sulfur from the product gas effluent and form a tail gas effluent;

15                   combusting a portion of the tail gas effluent with a source of oxygen in a combustion zone to oxidize sulfur species present in the tail gas effluent and form a combustion gas effluent comprising sulfur dioxide;

20                   contacting the combustion gas effluent with a liquid absorbent for sulfur dioxide in a sulfur dioxide absorption zone to selectively transfer sulfur dioxide from the combustion gas effluent to the absorbent and produce an exhaust gas from which sulfur dioxide has been substantially removed and a sulfur dioxide-rich absorbent;

25                   stripping sulfur dioxide from the rich absorbent in a sulfur dioxide stripping zone to produce a lean absorbent and a sulfur dioxide-enriched stripper gas;

recycling the lean absorbent to the sulfur dioxide absorption zone for further selective absorption of sulfur dioxide from the combustion gas effluent; and  
30 mixing the sulfur dioxide-enriched stripper gas with at least a portion of the acid gas feed stream and the remainder of the tail gas effluent to form the feed gas mixture introduced into the Claus catalytic reaction  
35 zone, the proportion of the tail gas effluent introduced into the Claus catalytic reaction zone as part of the feed gas mixture being sufficient to moderate the temperature within the Claus catalytic reaction zone.

2. The process as set forth in claim 1 wherein the temperature of the Claus conversion catalyst within the Claus catalytic reaction zone is maintained sufficiently low to inhibit hydrothermal aging of the catalyst.

3. The process as set forth in claim 2 wherein the Claus conversion catalyst comprises an alumina catalyst, the Claus catalytic reaction zone is maintained essentially free of oxygen and the temperature of the  
5 catalyst within the Claus catalytic reaction zone is maintained below about 480° C.

4. The process as set forth in claim 3 wherein the temperature of the Claus conversion catalyst within the Claus catalytic reaction zone is maintained from about 350° C to about 400° C.

5. The process as set forth in claim 2 wherein the Claus conversion catalyst comprises a titanium oxide catalyst and the temperature of the catalyst within the Claus catalytic reaction zone is maintained below about 600° C.

6. The process as set forth in claim 5 wherein the temperature of the Claus conversion catalyst within the Claus catalytic reaction zone is maintained from about 450° C to about 500° C.

7. The process as set forth in claim 1 wherein gas temperature within the Claus catalytic reaction zone is maintained from about 130° C to about 400° C.

8. The process as set forth in claim 1 wherein the acid gas feed stream contains at least about 30 mole percent hydrogen sulfide.

9. The process as set forth in claim 8 wherein the acid gas feed stream contains at least about 40 mole percent hydrogen sulfide.

10. The process as set forth in claim 9 wherein the acid gas feed stream contains at least about 50 mole percent hydrogen sulfide.

11. The process as set forth in claim 10 wherein the acid gas feed stream contains at least about 60 mole percent hydrogen sulfide.

12. The process as set forth in claim 8 wherein the acid gas feed stream is derived from a sour gas feed stock comprising hydrogen sulfide, the process further comprising:

5       contacting the sour gas feed stock with an absorbent for hydrogen sulfide to selectively transfer hydrogen sulfide from the sour gas feed stock to the absorbent and produce a hydrogen sulfide-rich absorbent; and

10       stripping hydrogen sulfide from the hydrogen sulfide-rich absorbent to produce the acid gas feed stream.

13. The process as set forth in claim 12 wherein the sour gas feed stock is selected from the group consisting of natural gas (and) offgas from petroleum refining, gas liquefaction or rubber vulcanization  
5       operations.

14. The process as set forth in claim 1 wherein sulfur dioxide is stripped from the sulfur dioxide-rich absorbent by contacting the rich absorbent with steam in the sulfur dioxide stripping zone and the sulfur dioxide-  
5       enriched stripper gas contains at least about 80 mole percent sulfur dioxide.

15. The process as set forth in claim 14 wherein the sulfur dioxide-enriched stripper gas contains at least about 90 mole percent sulfur dioxide.

16. The process as set forth in claim 14 wherein the sulfur dioxide stripping zone is maintained at a pressure of from about 50 kPa to about 60 kPa absolute.

17. The process as set forth in claim 1 wherein the molar ratio of hydrogen sulfide to sulfur dioxide in the feed gas mixture is from about 2:1 to about 5:1.

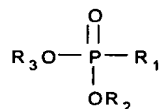
18. The process as set forth in claim 1 wherein the Claus catalytic reaction zone is operated at a conversion efficiency of from about 50% to about 70% based on the hydrogen sulfide content of the feed gas mixture.

19. The process as set forth in claim 1 wherein the liquid absorbent for sulfur dioxide contacted with the combustion gas effluent in the sulfur dioxide absorption zone is a physical sulfur dioxide absorbent.

20. The process as set forth in claim 19 wherein the combustion gas effluent comprises at least about 5 mole percent sulfur dioxide.

21. The process as set forth in claim 19 wherein the liquid absorbent for sulfur dioxide comprises at

least one substantially water immiscible organic phosphonate diester of the formula



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wherein R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently aryl or C<sub>1</sub> to C<sub>8</sub> alkyl, the organic phosphonate diester having a vapor pressure less than about 1 Pa at 25° C and the solubility of water in the organic phosphonate diester being less than about 10 weight percent at 25° C.

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22. The process as set forth in claim 21 wherein the at least one organic phosphonate diester is a dialkyl alkyl phosphonate and R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently C<sub>1</sub> to C<sub>6</sub> alkyl.

23. The process as set forth in claim 22 wherein the liquid absorbent for sulfur dioxide comprises dibutyl butyl phosphonate.

24. The process as set forth in claim 19 wherein the liquid absorbent for sulfur dioxide comprises tetraethyleneglycol dimethylether.

25. The process as set forth in claim 24 wherein the liquid absorbent for sulfur dioxide comprises more than 50% by weight tetraethyleneglycol dimethylether.

26. The process as set forth in claim 1 wherein the acid gas feed stream further comprises an unsaturated hydrocarbon component selected from the group consisting of linear olefins and branched olefins, aromatic hydrocarbons and mixtures thereof, the process further comprising pretreating the acid gas feed stream upstream of the Claus catalytic reaction zone to reduce the concentration of the unsaturated hydrocarbon component and inhibit deactivation of the Claus conversion catalyst, pretreatment of the acid gas feed stream comprising:
- 10                   contacting at least a portion of the acid gas feed stream with an aqueous acid wash to react unsaturated hydrocarbons with the acid and form an addition reaction
- 15                   product; and
- separating the addition reaction product from the acid gas feed stream.

27. The process as set forth in claim 26 wherein the aqueous acid wash comprises sulfuric acid and the addition reaction product comprises a sulfate reaction product.

28. The process as set forth in 27 wherein the addition reaction product separated from the acid gas feed stream is introduced into the combustion zone.

29. The process as set forth in claim 26 wherein the acid gas feed stream further comprises a saturated hydrocarbon component, the process further comprising:

maintaining a stoichiometric excess of sulfur  
5 dioxide over reductant gases in the Claus catalytic reaction zone; and

maintaining a temperature within the Claus catalytic reaction zone of at least about 300° C to substantially completely oxidize saturated hydrocarbons present in the  
10 feed gas mixture and inhibit formation of soot deposits comprising elemental carbon on the Claus conversion catalyst.

30. The process as set forth in claim 29 wherein a portion of the acid gas feed stream is bypassed around the Claus catalytic reaction zone and introduced directly into the combustion zone to thereby increase the sulfur  
5 dioxide concentration in the Claus catalytic reaction zone.

31. The process as set forth in claim 1 wherein the acid gas feed stream further comprises a hydrocarbon component selected from unsaturated hydrocarbons, saturated hydrocarbons and mixtures thereof, the Claus  
5 conversion catalyst having soot comprising elemental carbon deposited thereon due to incomplete oxidation of hydrocarbons contained in the acid gas feed stream, the process further comprising:



removing soot deposited on the Claus conversion catalyst by maintaining a stoichiometric excess of sulfur dioxide over reductant gases in the Claus catalytic reaction zone and a temperature of at least about 300°C within the Claus catalytic reaction zone for a time sufficient to oxidize elemental carbon present in the soot, the temperature within the Claus catalytic reaction zone being maintained at a temperature of at least about 300° C by controlling the proportion of the tail gas effluent introduced into the Claus catalytic reaction zone as part of the feed gas mixture.

32. The process as set forth in claim 31 wherein at least a portion of the acid gas feed stream is bypassed around the Claus catalytic reaction zone and introduced directly into the combustion zone to thereby increase the sulfur dioxide concentration in the Claus catalytic reaction zone.

33. A process for the production of elemental sulfur from an acid gas feed stream containing hydrogen sulfide and an unsaturated hydrocarbon component selected from the group consisting of linear olefins, branched olefins, aromatic hydrocarbons and mixtures thereof, the process comprising oxidizing hydrogen sulfide from the acid gas feed stream to elemental sulfur in a catalytic reaction zone containing an oxidation catalyst and supplied with an oxidant gas, wherein the improvement comprises pretreating the acid gas feed stream upstream

of the catalytic reaction zone to reduce the concentration of the unsaturated hydrocarbon component and inhibit deactivation of the oxidation catalyst, pretreatment of the acid gas feed stream comprising:

15       contacting at least a portion of the acid gas feed stream with an aqueous acid wash to react unsaturated hydrocarbons with the acid and form an addition reaction product; and

20       separating the addition reaction product from the acid gas feed stream.

34. The process as set forth in claim 33 wherein the aqueous acid wash comprises sulfuric acid and the addition reaction product comprises a sulfate reaction product.

35. The process as set forth in claim 34 wherein the concentration of sulfuric acid in the aqueous acid wash is from about 1 percent to about 50 percent by weight.

36. The process as set forth in claim 33 wherein the concentration of the unsaturated hydrocarbon component in the acid gas feed stream is at least about 200 ppmv prior to pretreatment and is less than about 40  
5 ppmv after pretreatment.

37. The process as set forth in claim 36 wherein the concentration of the unsaturated hydrocarbon

component in the acid gas feed stream is less than about 30 ppmv after pretreatment.

~~38.~~ The process as set forth in claim 37 wherein the concentration of the unsaturated hydrocarbon component in the acid gas feed stream is less than about 20 ppmv after pretreatment.

~~39.~~ The process as set forth in claim 33 wherein the unsaturated hydrocarbon component of the acid gas feed stream comprises at least one compound selected from the group consisting of toluene and xylene.

40. The process as set forth in claim 33 wherein the acid gas feed stream is contacted with a spray of the aqueous acid wash and the acid gas feed stream is thereafter passed through a mist elimination device to  
5 separate the addition reaction product from the acid gas feed stream.

41. The process as set forth in claim 33 wherein the acid gas feed stream is contacted with the aqueous acid wash in a gas-liquid contact apparatus containing means for promoting mass transfer between the gas and  
5 liquid phases, the gas-liquid contact apparatus being selected from the group consisting of mist elimination devices, packed towers and tray columns.

42. The process as set forth in claim 41 wherein  
the acid gas feed stream is passed through a mist  
elimination device wetted with the aqueous acid wash  
whereby the acid gas feed stream is contacted with the  
aqueous acid wash and the addition reaction product is  
5 separated from the acid gas feed stream.